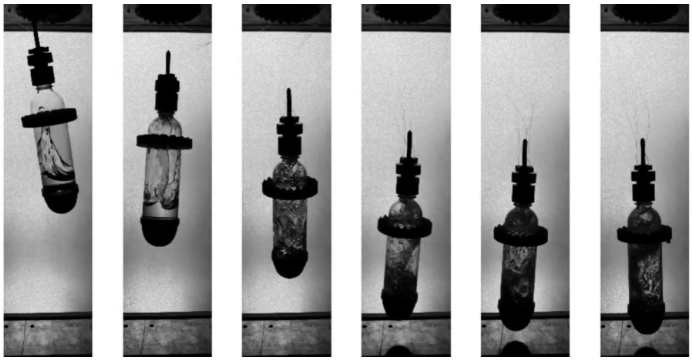
Controlling the Bounce of a Bottle

Dropping a rotating plastic bottle containing water results in a bounce whose height depends on the rotation rate.

By **David Ehrenstein**

With experiments that bring to mind **a social media challenge**, researchers demonstrated control over the bounce height of a dropped plastic bottle partially filled with water [**1**]. The team, led by Pablo Gutiérrez of O'Higgins University and Leonardo Gordillo of the University of Santiago, both in Chile, showed that initially spinning the bottle around a vertical axis strongly reduces the bounce height. The rotation forces water up along the walls, which, upon impact, generates a vertical jet in the center that can absorb much of the kinetic energy. Like a diver pushing downward on a diving board to gain height, the liquid in the jet pushes against the bottle as it moves upward, preventing the bottle from bouncing as high as it would if the water were quiescent.



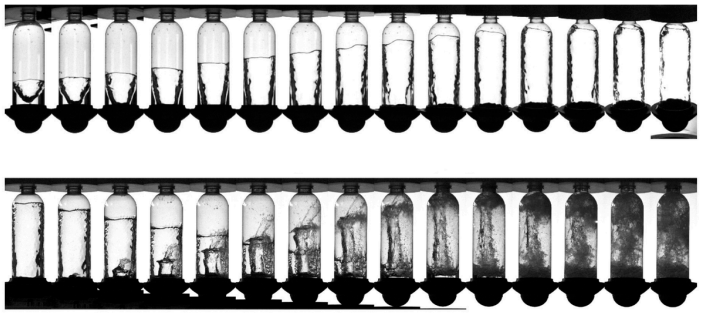
Dropping bottles partially filled with water results in bounce heights that depend on the speed of the initial rotation. The rotation rates vary (left to right) from 0 to 12 revolutions per second, and the shape of the fluid surface during free fall reflects the rotation rate (see still images below).
Credit: K. Andrade *et al.* [**1**]

While others have observed that fluid in a dropped container can affect its bounce [**2**], the new experiments are the first to use fluid rotation and the amount of water to systematically control the bounce height. The researchers developed a simple theory that agrees with the data and predicts that the most effective suppression of bouncing occurs with the highest rotation rates (they went up to 12.7 revolutions per second) and with the bottle about 40% full. They say that the mechanism they studied could apply to fluid transport in tank trucks or external fuel tanks of spacecraft, where planners could potentially reduce the effects of impacts by allowing extra volume in the container for fluid motion. The team encourages readers to try the experiments at home by swirling and dropping partially filled plastic bottles.

David Ehrenstein is a Senior Editor for ***Physics Magazine***.

REFERENCES

1. K. Andrade *et al.*, "Swirling fluid reduces the bounce of partially filled containers," **Phys. Rev. Lett. 130, 244001 (2023).**
2. T. W. Killian *et al.*, "Rebound and jet formation of a fluid-filled sphere," **Phys. Fluids 24, 122106 (2012).**



Bottling that energy. Images are shown in the bottle reference frame and are spaced equally in time. Top row: Water climbs the walls during free fall of a rotating bottle in a sequence that spans 375 ms in time from the moment of the drop to just before impact. Bottom row: This sequence spans 37 ms from impact until the central water jet disintegrates.
Credit: K. Andrade *et al.* [**1**]